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ABSTRACT

A study examined three variables derived from earlier research on comprehension and recall of narrative text: time in short-term memory; causal connections allowed; and referential connections allowed. Subjects, 84 randomly selected fourth graders in three suburban public elementary schools, read 8 short texts that each contained 4 embedded goals, and then orally recalled as much as they could remember from each text. Subjects' free recall was audiotaped, transcribed, and analyzed. Results indicated that: (1) causal chain status and number of causal relations were related to the memorability of a text; (2) readers retained the endmost proposition(s) from the causal chain in short-term memory as they read; (3) both the number of processing cycles that a proposition remains in short-term memory and the number of connections it forms to other propositions influenced its memorability; and (4) causal connections contributed to the coherence of a narrative text. Findings add support to the claim that short-term memory is a bottleneck in the comprehension process, and that the goal of narrative comprehension is to discover a sequence of causal links that connect a text's opening to its final outcome. (Two tables of data are included; 24 references are attached.) (RS)

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Running head: CAUSAL RELATIONS AND THEIR EFFECTS ON COMPREHENSION

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Causal Relations and Their Effects on the Comprehension of Narrative Texts

This study represents an effort to contribute to the growing body of research attempting to unify two separate approaches to the study of comprehension and recall of narrative text (Fletcher & Bloom, 1988; Slater, 1992; van den Broek, 1988). The first approach supported by the work of Trabasso and his colleagues (Trabasso & Sperry, 1985) describes comprehension as a problem-solving task in which the reader discovers a series of causal links that connect a narrative text's introduction to its conclusion. The second approach supported by the work of Kintsch and van Dijk (van Dijk & Kintsch, 1983) focuses on the importance of short-term memory as a hindrance in the comprehension process. Fletcher and Bloom (1988) merge these two approaches by assuming that the most likely causal antecedent to the next sentence is held in short term memory. From their perspective, this allows a reader to determine the causal structure of a text within the constraints of a limited-capacity short-term memory. The objectives of the present study are to examine three variables derived from their hypothesis: 1) time in short-term memory; 2) causal connections allowed; and 3) referential connections allowed to account for the percentage of the variance in fourth-graders' free recall from eight short narrative texts.

Theoretical Framework

Underlying the coherent representation of a text is an active process in which the reader finds connections between events by means of inferences (Collins, Brown, & Larkin, 1981; Fletcher, 1981; van den Broek, 1988). The inferences that unite events into a network of ideas are largely causal in nature (Black & Bower, 1980; Fletcher & Bloom,

1988; Graesser, 1981; Mandler & Johnson, 1977; Trabasso, Secco, & van den Broek, 1984). That is, the reader uses prior knowledge of psychological and physical causality to find causes and consequences of focal events, and thereby establishes coherence in text.

Using notions about causality from philosophy (Mackie, 1980; Toulmin, 1964); rhetoric (Corbett, 1990; Perelman & Olbrechts-Tyteca, 1969); artificial intelligence (Schank, 1975; Lehnert, 1978), and cognitive psychology (Mandler & Johnson, 1977; Stein & Glenn, 1979; Trabasso, Secco, & van den Broek, 1984), Trabasso and van den Broek have developed a general model for comprehension that identifies causal relations between events. The model represents events and their relations as causal networks and finds a critical, causal chain through the network that identifies the important events, states, and actions in the story.

Performance on various comprehension tasks such as question answering, priming, causal-chain events, and number of causal connections support the notion that readers, in an attempt to generate a coherent representation of a text, identify and infer causal relationships between the various components of the text (Liu, 1988). Direct causal connections between events constrain answers to questions and determine activation of one event by another (Suh, 1988). In addition, events that are on the causal path through the story and that have many connections are recalled and summarized more often and rated as more important than those that are dead end or have few connections (Black & Bower, 1980). These findings support the psychological validity and importance of individual causal connections between pairs of events as well as of the representation of the overall structure of a

narrative as a causal network. They also suggest that the Trabasso and van den Broek (1985) model for identifying the causal structure of a story captures important properties of readers' mental representation of a text.

Given this background, the following hypotheses were tested: 1) that Trabasso's causal analysis can be extended to the level of individual propositions; 2) that the propositions most useful for understanding the causal structure of a text are held in short-term memory during comprehension; 3) that both the amount of time a proposition spends in short-term memory and the number of connections this allows to other propositions influence its recall; and 4) that both referential and causal connections contribute to the coherence of a text.

Method

Subjects. Subjects for the study were 84 randomly selected fourth graders in three suburban public elementary schools. All subjects were native speakers of English.

Materials. Using methods, procedures, and analyses developed by Fletcher and Bloom (1988), eight short narrative texts were used in this research. Each consisted of 10 sentences and contained four embedded goals. The organization of these goals was systematically varied across texts. Specifically, four separate goal hierarchies (deep, shallow, unbalanced, and balanced) were generated and two texts were written to conform to each. The purpose of this manipulation was to produce variation in the effort required to hold the most subordinate goal in short-term memory. The more deeply embedded the goal structure, the greater the effort should become.

The eight texts were organized into two sets. Each set was composed so that four of the texts in each set were used as fillers and four were used as targets. Texts that were used as fillers in the first set were used as targets in the second set and vice versa. Each set included one target text corresponding to each of the four goal structures. Subjects were randomly assigned to each text set. Test booklets were constructed that contained a page of instructions followed by the eight texts in the following sequence: two filler texts at the beginning, four target texts, and two filler texts at the end, followed by free-recall instructions for each of the four target texts. Each subject recalled the target texts in the same order in which they had been presented. Each text and each recall were on a separate page.

Procedures. The experiments consisted of two phases. During the first phase, each subject was instructed to read the eight texts once through at his or her normal reading speed, paying close attention because later he or she would be asked to recall them. In the second phase, each subject was given the titles from the four middle texts on separate 3 x 5 index cards and instructed to orally recall as much as they could remember from each text, using the exact words if possible. All recalls were audiotaped and then transcribed for scoring.

Scoring. The propositional content of each text was derived using procedures recommended by Bovair and Kieras (1985) and Turner and Greene (1978). The resulting list of propositions was then used to score subjects' free-recall protocols. A strict scoring criteria was adopted such that a subject was credited with recalling a proposition only if it or a close paraphrase of it was explicitly present in the recall protocol. Two independent raters scored each protocol. Overall

agreement between raters was approximately 90% and all discrepancies were resolved through discussion. After the protocols were scored, the results were used to calculate the probability of recall for each proposition.

Results

Effects of Causal Structure. Multiple regression analyses were carried out on the recall probabilities of each proposition in each text. The independent variables were 1) whether or not a proposition was from a state on the causal chain (causal chain status), 2) the number of direct causal connections a proposition's state had with the other states in the text (causal connections possible) and 3) the number of direct referential connections a proposition had with the other propositions in the text (referential connections possible). Causal chain status was a categorical independent variable, with propositions from states on the causal chain receiving a score of one, and propositions not on the causal chain receiving a score of zero. All analyses were conducted on the eight texts combined as well as independently. Because of the theoretical relatedness of the independent variables, a check of multicolinearity was conducted (Pedhazur, 1982). The results of this check indicated no multicolinearity.

As Table 1 indicates, causal connections possible, causal chain status, and referential connections possible each accounted for significant proportions of variance when entered into the analysis alone. In addition, both causal chain status and causal connections possible uniquely accounted for significant proportions of variance,

Insert Table 1 about here

while referential connections possible failed to account for any significant unique variance. The interactions of causal chain status with both referential connections possible and causal connections possible were not significant. These results support the findings reported by Trabasso and van den Broek (1985), Fletcher and Bloom (1988), and Slater (1992). However, like the Fletcher and Bloom (1988) and Slater (1992) studies, they extend those findings to individual propositions.

Effects of Short-Term Memory Allocation. Each of the short-term memory allocation strategies tested in the earlier studies (leading edge, current-state, or current state plus goal) was fit to the free-recall data in two steps. First , a minimum X^2 criterion was used to find the value of p which produces the best fit between predicted and observed recall probabilities in the equation $Pr(recall) = 1-(1-p)^k$ for each combination strategy and text. This provides a measure of how time in short term-memory alone influences free recall. Next, separate multiple regression analyses on the probability of recall were computed for each strategy, using three independent variables: 1) time in short-term memory, 2) the number of direct causal connections a proposition's state had with the other states as allowed by their co-occurrence in short-term memory (causal connections allowed), and 3) the number of direct referential connections a proposition had with other propositions as allowed by their co-occurrence in short-term memory (referential connections allowed). Independent variables were

checked for multicolinearity. None was found. Again, the effects of text and its interactions with the other variables were nonsignificant, so all results are presented with the texts combined.

All three full models account for significant amounts of variance while the current-state model accounts for the most, .26, $p < .01$. Next is the current-state plus goal model, .22, $p < .001$, and then the leading-edge model, .16, $p < .001$. Within the current-state model, all three variables individually account for significant proportions of variance, time in short-term memory, .19, $p < .001$, causal connections allowed, .20, $p < .001$, and referential connections allowed, .02, $p < .05$. However, only time in short-term memory and causal connections allowed accounted for significant amounts of unique variance, .04, $p < .01$ and .06, $p < .01$, respectively.

Comparison of Structural and Processing Analyses. A direct comparison of the variables employed in the structural analyses (causal chain status, causal connections possible, and referential connections possible) with the variables employed in the processing analyses (time in short-term memory, causal connections allowed, and referential connections allowed). As Table 2 indicates, this analysis revealed that although both the structural and processing analysis variables alone account for significant amounts of variance, the processing

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Insert Table 2 about here

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analysis variables from the current-state model accounted for both more variance and a significant amount of unique variance.

Discussion

Several important findings are derived from this study and confirm findings in earlier studies (Trabasso & van den Broek, 1985; Fletcher & Bloom, 1988). First, Trabasso and van den Broek's (1985) finding that causal chain status and number of causal relations are related to the memorability of a text is supported. Second, findings support the notion that readers retain the endmost proposition(s) from the causal chain in short-term memory as they read. This is consistent with the general outline of the comprehension model proposed by Kintsch and van Dijk (1978). Third, findings support the contention that both the number of processing cycles that a proposition remains in short-term memory and the number of connections it forms to other propositions influence its memorability. Fourth, straightforward support from the data indicate that causal connections contribute to the coherence of a narrative text. But as in previous studies, the importance of referential connections remains less clear.

This study makes a contribution to the evolving line of inquiry which is attempting to integrate two approaches to the study of text comprehension and recall. The data support the claim that the goal of narrative comprehension is to discover a sequence of causal links that connect a text's opening to its final outcome. Additionally, the data support the view of short-term memory as a bottleneck in the comprehension process. It appears that readers use local causal relations to identify the propositions that are the most likely antecedents of the next sentence they read. Held in short-term memory, these propositions allow readers to discover a causal path through a text within the constraints imposed by short-term memory. It is

interesting that goal information appears not to be held in short-term memory. Goals are probably reinstated whenever local coherence breaks down.

Future research needs to investigate the conditions under which long-term memory is searched for missing antecedents or consequences. In addition, future research needs to systematically extend and replicate these findings with longer and more ecologically valid texts.

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Table 1

Proportions of Variance Accounted for by Causal Connections Possible, Causal Chain Status, and Referential Connections Possible

	R^2	
	Alone	Unique
	Full Model = .22**	
Causal Connections Possible	.17***	.02**
Causal Chain Status	.19***	.04**
Referential Connections Possible	.01*	.00

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 2

Proportions of Variance Accounted for by both the Structural Analysis and the Processing Analysis Variables

	R^2	
	Alone	Unique
Structural analysis variables	.22***	.02
Processing analysis variables	.26***	.05*

* $p < .05$.

*** $p < .001$.